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Type conformance test report of the of the IEC-60870-5-104 protocol implementation in the IPCOMM IpConv

Tested as Controlled station implementation in Normal and Reversed direction

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Author P.H.S. Ermens
KEMA Consulting

On behalf of IPCOMM GmbH, Germany

author:	P.H.S. Ermens	2008-02-28	reviewed:	R. Lassche	2008-02-28
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1 INTRODUCTION

1.1 Background

IPCOMM has implemented the IEC 60870-5 Telecontrol Companion Standard 104 in the IpConv gateway for communication with a controlling system. The IEC 60870-5 Telecontrol Companion Standard 104 (TCS104) can be used as a communication protocol for exchanging information between Control Center(s) (controlling station) and their substations (controlled station(s)). The information exchanged can be for example measurands, status messages and commands.

KEMA's assignment was to answer the following question:

"Does the IEC 60870-5-104 controlled station protocol implementation in the IPCOMM IpConv conform to the IEC 60870-5-104 Companion Standard in Standard and Reversed Direction?"

To answer this question, KEMA has performed a **type conformance test** of the IEC 60870-5-104 protocol implementation in the IPCOMM IpConv controlled station implementation, further mentioned as System Under Test (SUT).

1.2 Testing viewpoints

There are two viewpoints for testing: **Type testing** and **Interoperability testing**.

The first testing viewpoint, **Type testing,** is the process of verifying that an implementation performs in accordance with a particular standard. A manufacturer may claim: "*my equipment conforms to standard ISO/IEC xxx-x* ". Type testing enables such a claim to be investigated and assessed by an objective and independent institute, like KEMA, to establish its validity. The type test may result in certification by means of an Attestation of Conformity, guaranteed by KEMA, for the tested implementation version in that equipment. KEMA maintains a list of type-tested and approved equipment with IEC 60870-5 implementations (see www.kema.com/pctc).

Type testing extends the normal conformance test process by adding negative and boundary test items to the testing process.

The second viewpoint, **Interoperability testing (IOP)**, shows whether or not a protocol implementation, installed in one product, can be used to exchange information with another product which has implemented the same protocol. No direct attention is paid to the

implementation of the protocol itself. After completion of the tests, there is no guarantee that the protocol implementation is in accordance with that particular standard. It is clear, however, whether or not the protocol functions required in order to exchange information can work together to accomplish the required task.

1.3 Purpose of this document

The purpose of this document is to describe the results of the type test of the IEC 60870-5-104 implementation in the System Under Test [further SUT]. The type test was executed on location of IPCOMM GmbH, Gundstrasse 15, Erlangen, Germany from February 18th till February 20th 2008.

1.4 Contents of this document

Chapter 2 shows the list of relevant normative and other references, used to provide input for the type test.

Chapter 3 describes the various relevant components for the type test and their configuration as used in the type test, including the System Under Test. This chapter also gives an overview and introduction to the various test groups that together constitute the type test.

Chapter 4 and 5 give an overview and summary of the test results, the conclusion(s) and recommendations based on the conclusions. The summary contains two **defect** categories for defects found during the type test: a **Major** category and a **Minor** category. Also a **Remarks** category is introduced. These categories are further explained in this chapter.

Chapter 6 contains the Protocol Implementation Conformance Statement of the SUT.

Appendix A specifies the detailed test cases and their outcome, appendix B contains detailed comments on test results for commands.

1.5 Glossary

- SUT = System Under Test.
- PICS = Protocol Implementation Conformance Statement

2 REFERENCES

2.1 Normative

The tests defined in this document are based on the following IEC (International Electrotechnical Committee) documents in the IEC 60870-5 range: Telecontrol equipment and systems part 5: Transmission protocols:

1. IEC 60870-5-1: TELECONTROL EQUIPMENT AND SYSTEMS, PART 5, Transmission protocols: Transmission Frame Formats, IS (International Standard), 1990, further referred to as [IEC5-1]
2. IEC 60870-5-2: TELECONTROL EQUIPMENT AND SYSTEMS, PART 5, Transmission protocols: Link Transmission Procedures, IS, 1992, further referred to as [IEC5-2]
3. IEC 60870-5-3: TELECONTROL EQUIPMENT AND SYSTEMS, PART 5, Transmission protocols: General Structure of Application Data, IS, 1992, further referred to as [IEC5-3]
4. IEC 60870-5-4: TELECONTROL EQUIPMENT AND SYSTEMS, PART 5, Transmission protocols: Definition and Coding of Application Information Elements, IS, 1993, further referred to as [IEC5-4]
5. IEC 60870-5-5: TELECONTROL EQUIPMENT AND SYSTEMS, PART 5, Transmission protocols: Basic Application Functions, IS, 1995, further referred to as [IEC5-5]
6. IEC 60870-5-101: TELECONTROL EQUIPMENT AND SYSTEMS, PART 5, Transmission protocols: Companion standard for basic telecontrol tasks, IS, second edition 2003-02, further referred to as [IEC5-101]
7. Addendum 1 (A1) to [IEC5-101] extension of time tags
8. Addendum 2 (A2) to [IEC5-101] Supplementary Definitions to IEC 60870-5-101, revision 7
9. IEC 60870-5-104: TELECONTROL EQUIPMENT AND SYSTEMS, PART 5, Transmission protocols: Network access for IEC 60870-5-101 using standard transport profiles, IS, second edition, further referred to as [IEC5-104]
10. IEC 60870-5-604: Telecontrol equipment and systems, Part 5-604, Conformance test cases for the IEC 60870-5-104 Companion Standard.

2.2 Other

1. IPCOMM IpConv interoperability table, February 2008, Version 1.5.

3 THE TYPE TEST

3.1 Components in the test environment

The test environment consists of the following components:

- The System Under Test [SUT]: the IPCOMM IpConv controlled station implementation software version 3.2 (19-02-2008)
- The KEMA UnIECim-104 version 1.16.02 (December 2007) protocol test platform, which runs the TCS104 simulator test suite version 1.28 and acts as a single-node Controlling station
- NetGear Fast Ethernet Switch
- RJ45 100 Mb cables.

The configured IP-addresses during the test (192.168.1.*):

- System under test: .100
- Testsystem: .101 and .102.

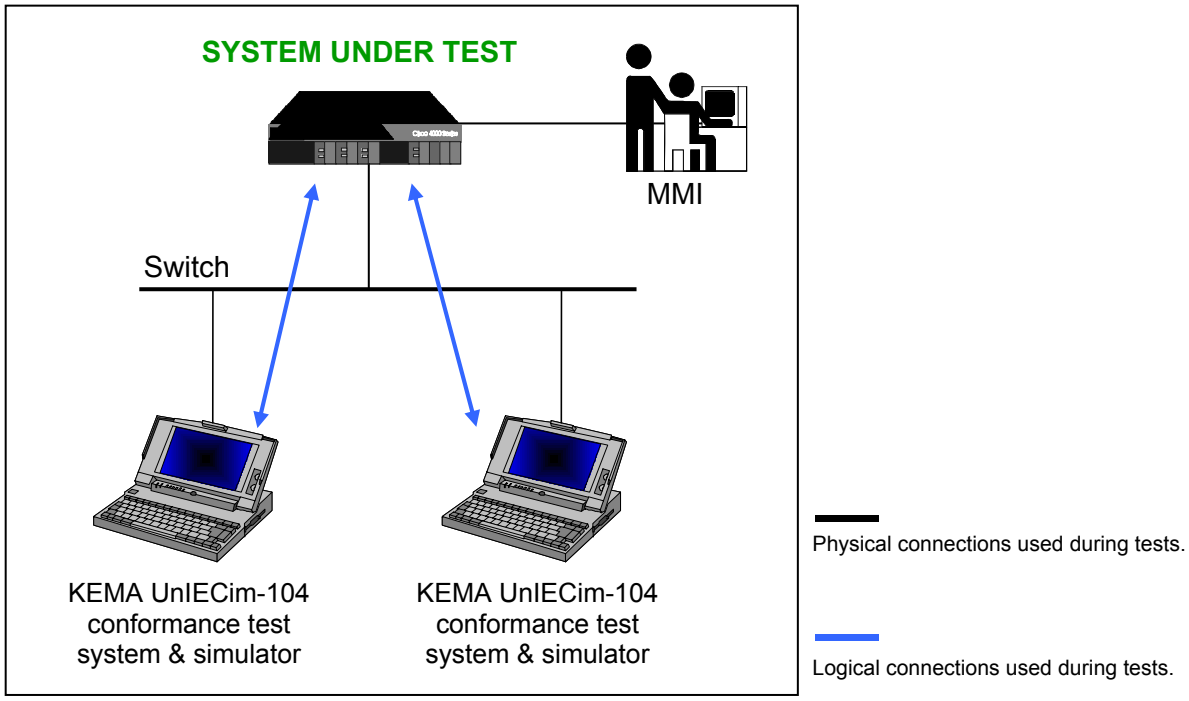

Figure 3.1 Connection and set-up of the test environment

3.1.1 SUT requirements

Next to the CS104 communication capability specified in the PID, the System Under Test must support the following requirements for control and simulation purposes during testing, e.g. via additional test equipment attached to the SUT or one or more configured and running operator MMI stations:

- display the current values of the Information Elements described in I/O list, mapped to visible MMI-elements
- manually pause/freeze (or equivalent, e.g. extending timers) of the communication to verify displayed or analysed data
- manually shut down and restart or equivalent
- manually cut-off of the connection to the communication link
- manually activate the supported Basic Application Functions
- direct physical connection to the communication link.

3.1.2 SUT configuration

The configuration of the SUT is as follows:

- The telecontrol communication mode is balanced (by definition) peer-to-peer, capable of using a Wide Area TCP/IP network (see figure 3.1)
- IP address detail as in figure 3.1, besides other configuration details
- Common Addresses of ASDU (CAA) used during the test were 1 and 2.
- Further details of the implemented protocol (interoperability sheet) subset can be found in chapter 6 Protocol Implementation Conformance Statement (PICS)
- The Protocol Implementation Conformance Statement forms the basis for the applicable test cases in the test plan in Appendix A.

3.1.3 UnIECim test system requirements

The UnIECim IEC 60870-5 protocol test platform is KEMA's test system for testing IEC 60870-5 protocol implementations. The knowledge of the IEC 60870-5 protocol is in the software. UnIECim 60870-5 supports real-time data capturing, analysis and decoding, combined with construction of frames and real-time script execution for simulation of conforming (positive) as well as non-conforming (negative) communication functions. UnIECim automatically executes all scripts (test cases) in a so-called test suite.

UnIECim 60870-5-***104*** is the test tool for testing Controlling or Controlled station implementations based on the IEC 60870-5 Telecontrol Companion Standard 104 (TCS 104) Network access for IEC 60870-5-101 including redundancy functionality.

3.1.4 Communication link requirements

The data communication network must support the following requirements for testing:

- TCP/IP and Ethernet as defined in [5-104]
- The connection is made by using a RJ45 patch cable, Ethernet pin configuration
- "Normal" performance and with a minimum of other than TCS104 traffic on the network.

3.1.5 Information object configuration

Tables 3.1 and 3.2 show the configured Information Object Addresses in monitoring and control direction, respectively.

Table 3.1 Configured Information objects in the Controlled station for ASDU's in monitor direction

IOA	Description	ASDU Type	GI	Time tag
On request	Single point information	1	Y	N
On request	Double point information	3	Y	N
On request	Step position information	5	Y	N
On request	Bit string of 32 bit	7	Y	N
On request	Measured value, Normalised	9	Y	N
On request	Measured value, Scaled value	11	Y	N
On request	Measured value, Short floating point	13	Y	N
On request	Integrated Totals	15	N	N
On request	Single point information with time tag	30	N	Y
On request	Double point information with time tag	31	N	Y
On request	Step position information with time tag	32	N	Y
On request	Bit string of 32 bit with time tag	33	N	Y
On request	Measured value, Normalised with time tag	34	N	Y
On request	Measured value, Scaled value with time tag	35	N	Y
On request	Measured value, Short floating point with time tag	36	N	Y
On request	Integrated totals with time tag	37	N	Y
On request	Event of protection equipment with time tag	38	N	Y
On request	Packed start events of protection equipment with time tag	39	N	Y
On request	Packed output circuit info of protection equipment with time tag	40	N	Y

Table 3.2 Configured Information objects in the Controlling station for ASDU's in control direction

IOA	Description	ASDU Type
On request	Single command	45
On request	Double command	46
On request	Regulation step command	47
On request	Set point command, normalised	48
On request	Set point command, scaled value	49
On request	Set point command, short float point	50
On request	Bit string command	51
On request	Single command with time tag	58
On request	Double command with time tag	59
On request	Regulation step command with time tag	60
On request	Set point command, normalised with time tag	61
On request	Set point command, scaled value with time tag	62
On request	Set point command, short float point with time tag	63
On request	Bit string command with time tag	64
On request	Parameter of measured value, Normalised	110
On request	Parameter of measured value, Short floating point	112

3.2 Overview of the test suite

3.2.1 Tests on Transport provider level

For information exchange between both end systems a TCP/IP network is used. Tests on Transport provider level verify that end systems can establish a TCP/IP connection, are able to exchange (CS104) messages and the TCP/IP connection doesn't fail permanently. White-box (internal) TCP/IP and lower tests are *not* performed. The tests are passed if no error is reported during a test session.

3.2.2 Tests on application level

Most of the Application Service Data Units (ASDUs) tests defined in Appendix A are automatically performed by the UnIECim test tool on each received ASDU if applicable. The tests are passed if no error is reported during a test session.

The Basic Application Functions (BAFs) tests defined in Appendix A are performed by a combination of automatic verification and manual expert analysis for each test case if applicable. The tests have passed if no defect is found during a test session.

3.2.3 **Negative tests**

The Negative tests defined in Appendix A table 24 are performed by a combination of automatic verification and manual expert analysis for each test case if applicable. The tests have passed if the SUT continues correct operation, that is: does not send corrupted frames and reacts in a correct and sensible manner.

The SUT may not fail permanently when receiving:

- corrupted frames
- illegal functions
- not supported functions
- not supported Basic Application Functions (BAF) or ASDU's.

4 TEST RESULTS

Table 4.1 in this Chapter gives a summary of the type test results. Numbers shown in the table columns refer to test numbers of individual test cases in appendix A.

Major defects are a **certain** cause for operational risks: these MUST be corrected before going into an operational situation! They imply the test is **failed.**

A **minor** defect is non-conformant behaviour, and can have a negative influence on the use of the product *in specific configurations*. Minor defects are a potential cause for operational problems. Therefore in a type test they also imply the test is **failed**.

In an interoperability test a minor defect **could pass** the test, depending on the severity of the defect. In configurations with different products and/or different manufacturers these minor defects in the implementation are a potential risk for the interoperability when not taken into account before going into an operational situation.

Finally, **remarks** introduce additional observations about the test case results, like limitations in the implementation.

The Protocol Implementation Conformance Statement (PICS) in chapter 6 is the basis for the applicable test cases in Appendix A. The PICS gives an overview of the tested protocol implementation, but this isn't a guarantee that the complete function or ASDU, as enabled in the PICS, is tested and supported. Partial testing is possible and the completeness of the tests for the specific function or ASDU must be consulted in Appendix A.

Table 4.1 Summary of test results for the System Under Test

Test group	Major	Minor	Remarks	Verdict
0. Configuration parameters			-	Passed
1. Transport provider level			5.3.1.50	Passed
2. Data Unit Identifier			-	Passed
3. ASDUs for Process information in monitor (Normal) direction			-	Passed
4. ASDUs for process information in control direction			5.3.4.1, 5.3.4.10, 5.3.4.20, 5.3.4.70, 5.3.4.90,5.3.4.110	Passed
5. ASDUs for system information in monitor direction			5.3.5.1	Passed
6. ASDU for system information in control direction			-	Passed
7. ASDU for parameters in control direction			-	Passed
8. ASDU for file transfer in monitor and control direction			-	N/A
9. Data Unit Identifier			-	Passed
10. Information object address			-	Passed
11. Station initialisation			-	Passed
12. Redundant connection tests			5.4.12.1	Passed
13. Cyclic data transmission			-	Passed
14. Data acquisition through Read			-	Passed
15. Acquisition of events			-	Passed
16. General interrogation			5.4.16.1	Passed
17. Clock synchronisation			-	Passed
18. Command transmission			5.4.18.1, 5.4.18.20	Passed
19. Transmission of integrated totals			-	Passed
20. Parameter loading			5.4.20.10	Passed
21. Test procedure			-	Passed
22. File Transfer			-	N/A
23. Additional tests			5.4.23.10	Passed
24. Negative tests			-	Passed
25. PIXIT related			-	N/A
TOTALS	**0**	**0**		**Passed**

* N/a = Not Applicable

5 CONCLUSION AND RECOMMENDATIONS

The assignment was to give a well-founded answer to the question:

"Does the IEC 60870-5-104 controlled station protocol implementation in the IPCOMM IpConv conform to the IEC 60870-5-104 Companion Standard in Standard and Reversed Direction?"

Based on the test results described in this report, KEMA declares the tested CS104 implementation in the IPCOMM controlled station implementation in conformance with the IEC 60870-5-104 standard [IEC 5-104] and the [PICS] for the tested configuration.

5.1 Exceptions with the [PICS]

The following extra functionality is implemented:

- Redundancy groups. If an event occurs, and one of the connections is stopped or not connected, then the event will be retransmitted when that connections becomes started again. This is tested with 2 connections from different IP addresses. Each connection was configured as a separate redundancy group.

5.2 Recommendations following from the test

The following recommendations apply for the tested system configuration:

- For the End of Init (ASDU type 70), the SUT could only send COI = 0. It is recommended to also support values 1 and 2 to differentiate between the reasons for the reset.

6 PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT (PICS)

The Protocol Implementation Conformance Statement (PICS) in this paragraph is the basis for the applicable test cases in Appendix A. This PICS gives an overview of the tested protocol implementation, but this isn't a guarantee that the complete function or ASDU, as enabled in the PICS, is tested and supported. Partial testing is possible and the completeness of the tests for the specific function or ASDU must be consulted in Appendix A.

Note:
In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

The selected parameters should be marked in the white boxes as follows:

- ☐ Function or ASDU is not used
- ☒ Function or ASDU is used as standardized (default)
- ☒ Function or ASDU is used in reverse mode
- ☒ Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific clause or parameter.

A black check box indicates that the option cannot be selected in this companion standard.

6.1 System or device

(system-specific parameter, indicate definition of a system or a device by marking one of the following with '**X**')

- ☐ System definition
- ☐ Controlling station definition
- ☒ Controlled station definition

6.2 Network configuration

(network-specific parameter, all configurations that are used are to be marked '**X**')

- ■ ~~Point-to-point~~
- ■ ~~Multiple point-to-point~~
- ■ ~~Multipoint~~
- ■ ~~Multipoint star~~

6.3 **Physical layer**

(network-specific parameter, all interfaces and data rates that are used are to be marked '**X**')

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200bit/s	Balanced interchange Circuit X.24/X.27	
■ ~~100 bit/s~~	■ ~~2 400 bit/s~~	■ ~~2 400 bit/s~~	■ ~~56 000 bit/s~~
■ ~~200 bit/s~~	■ ~~4 800 bit/s~~	■ ~~4 800 bit/s~~	■ ~~64 000 bit/s~~
■ ~~300 bit/s~~	■ ~~9 600 bit/s~~	■ ~~9 600 bit/s~~	
■ ~~600 bit/s~~		■ ~~19 200 bit/s~~	
■ ~~1 200 bit/s~~		■ ~~38 400 bit/s~~	

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200bit/s	Balanced interchange Circuit X.24/X.27	
■ ~~100 bit/s~~	■ ~~2 400 bit/s~~	■ ~~2 400 bit/s~~	■ ~~56 000 bit/s~~
■ ~~200 bit/s~~	■ ~~4 800 bit/s~~	■ ~~4 800 bit/s~~	■ ~~64 000 bit/s~~
■ ~~300 bit/s~~	■ ~~9 600 bit/s~~	■ ~~9 600 bit/s~~	
■ ~~600 bit/s~~		■ ~~19 200 bit/s~~	
■ ~~1 200 bit/s~~		■ ~~38 400 bit/s~~	

6.4 Link layer

(network-specific parameter, all options that are used are to be marked 'X'. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the Type ID and COT of all messages assigned to class 2.)

~~Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.~~

Link transmission

- [ ] ~~Balanced transmission~~
- [ ] ~~Unbalanced transmission~~

Address field of the link

- [ ] ~~not present (balanced transmission only)~~
- [ ] ~~One octet~~
- [ ] ~~Two octets~~
- [ ] ~~structured~~
- [ ] ~~unstructured~~

Frame

- [ ] ~~Maximum length L (number of octets)~~

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

- [ ] ~~The standard assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission
9, 11, 13, 21	<1>

- [ ] ~~A special assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission

~~Note: (In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available).~~

6.5 Application layer

Transmission mode for application data
Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU
(system-specific parameter, all configurations that are used are to be marked '**X**')

- ■ ~~One octet~~
- [X] Two octets

Information object address
(system-specific parameter, all configurations that are used are to be marked '**X**')

- ■ ~~One octet~~
- ■ ~~Two~~
- [X] Three octets
- [X] structured
- [X] unstructure

Cause of transmission
(system-specific parameter, all configurations that are used are to be marked '**X**')

- ■ ~~One octet~~
- [X] Two octets (with originator address) Originator address is set to zero if not used

Length of APDU
(system-specific parameter, specify the maximum length of the APDU per system)

The maximum length of the APDU is 253 (default). The maximum length may be reduced per system.

253 Maximum length of APDU per system

Selection of standard ASDUs

Process information in monitor direction
(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

B	<1>	:=	Single-point information	M_SP_NA_1
■	~~<2>~~	~~:=~~	~~Single-point information with time tag~~	~~M_SP_TA_1~~
B	<3>	:=	Double-point information	M_DP_NA_1
■	~~<4>~~	~~:=~~	~~Double-point information with time tag~~	~~M_DP_TA_1~~
B	<5>	:=	Step position information	M_ST_NA_1
■	~~<6>~~	~~:=~~	~~Step position information with time tag~~	~~M_ST_TA_1~~
B	<7>	:=	Bitstring of 32 bit	M_BO_NA_1
■	~~<8>~~	~~:=~~	~~Bitstring of 32 bit with time tag~~	~~M_BO_TA_1~~
B	<9>	:=	Measured value, normalized value	M_ME_NA_1
■	~~<10>~~	~~:=~~	~~Measured value, normalized value with time tag~~	~~M_ME_TA_1~~
B	<11>	:=	Measured value, scaled value	M_ME_NB_1
■	~~<12>~~	~~:=~~	~~Measured value, scaled value with time tag~~	~~M_ME_TB_1~~
B	<13>	:=	Measured value, short floating point value	M_ME_NC_1
■	~~<14>~~	~~:=~~	~~Measured value, short floating point value with time tag~~	~~M_ME_TC_1~~
B	<15>	:=	Integrated totals	M_IT_NA_1
■	~~<16>~~	~~:=~~	~~Integrated totals with time tag~~	~~M_IT_TA_1~~
■	~~<17>~~	~~:=~~	~~Event of protection equipment with time tag~~	~~M_EP_TA_1~~
■	~~<18>~~	~~:=~~	~~Packed start events of protection equipment with time tag~~	~~M_EP_TB_1~~
■	~~<19>~~	~~:=~~	~~Packed output circuit information of protection equipment with time tag~~	~~M_EP_TC_1~~
	<20>	:=	Packed single-point information with status change detection	M_PS_NA_1
	<21>	:=	Measured value, normalized value without quality descriptor	M_ME_ND_1

B	<30>	:=	Single-point information with time tag CP56Time2a	M_SP_TB_1
B	<31>	:=	Double-point information with time tag CP56Time2a	M_DP_TB_1
B	<32>	:=	Step position information with time tag CP56Time2a	M_ST_TB_1
B	<33>	:=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
B	<34>	:=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
B	<35>	:=	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
B	<36>	:=	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
B	<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
X	<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
X	<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
X	<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either the ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, <19> or of the set <30> – <40> are used.

Process information in control direction
(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

X	<45> :=	Single command	C_SC_NA_1
X	<46> :=	Double command	C_DC_NA_1
X	<47> :=	Regulating step command	C_RC_NA_1
X	<48> :=	Set point command, normalized value	C SE NA 1
X	<49> :=	Set point command, scaled value	C_SE_NB_1
X	<50> :=	Set point command, short floating point value	C_SE_NC_1
X	<51> :=	Bitstring of 32 bit	C_BO_NA_1
X	<58> :=	Single command with time tag CP56Time 2a	C_SC_TA_1
X	<59> :=	Double command with time tag CP56Time 2a	C_DC_TA_1
X	<60> :=	Regulating step command with time tag CP56Time 2a	C_RC_TA_1
X	<61> :=	Set point command, normalized value with time tag CP56Time 2a	C SE TA 1
X	<62> :=	Set point command, scaled value with time tag CP56Time 2a	C_SE_TB_1
X	<63> :=	Set point command, short floating point value with time tag CP56Time 2a	C_SE_TC_1
X	<64> :=	Bitstring of 32 bit with time tag CP56Time 2a	C_BO_TA_1

Either the ASDUs of the set <45> – <51> or of the set <58> – <64> are used.

System information in monitor direction
(station-specific parameter, mark '**X**' if used)

B	<70> :=	End of initialization	M_EI_NA_1

System information in control direction
(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

B	<100>:=	Interrogation command	C_IC_NA_1
B	<101>:=	Counter interrogation command	C_CI_NA_1
X	<102>:=	Read command	C_RD_NA_1
X	<103>:=	Clock synchronization command	C_CS_NA_1
	~~<104>:=~~	~~Test command~~	~~C_TS_NA_1~~
X	<105>:=	Reset process command	C_RP_NA_1
	~~<106>:=~~	~~Delay acquisition command~~	~~C_CD_NA_1~~
B	<107>:=	Test command with time tag CP56time2a	C_TS_TA_1

Parameter in control direction
(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X]	<110>:=	Parameter of measured value, normalized value	P_ME_NA_1
[ ]	<111>:=	Parameter of measured value, scaled value	P_ME_NB_1
[X]	<112>:=	Parameter of measured value, short floating point value	P_ME_NC_1
[ ]	<113>:=	Parameter activation	P_AC_NA_1

File Transfer
(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[ ]	<120>:=	File ready	F_FR_NA_1
[ ]	<121>:=	Section ready	F_SR_NA_1
[ ]	<122>:=	Call directory, select file, call file, call section	F_SC_NA_1
[ ]	<123>:=	Last section, last segment	F_LS_NA_1
[ ]	<124>:=	Ack file, ack section	F_AF_NA_1
[ ]	<125>:=	Segment	F_SG_NA_1
[ ]	<126>:=	Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

Type Identifier and Cause of Transmission Assignments
(station-specific parameters)

Shaded boxes are not required.
Black boxes are not permitted in this companion standard
Blank = Function or ASDU is not used.
Mark Type Identification/Cause of transmission combinations:
'**X**' if only used in the standard direction
'**R**' if only used in the reverse direction
'**B**' if used in both directions

Type Identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1	X	X	B								X			B					
~~<2>~~	~~M_SP_TA_1~~																			
<3>	M_DP_NA_1	X	X	B								X			B					
~~<4>~~	~~M_DP_TA_1~~																			
<5>	M_ST_NA_1	X	X	B								X			B					
~~<6>~~	~~M_ST_TA_1~~																			
<7>	M_BO_NA_1	X	X	B											B					
~~<8>~~	~~M_BO_TA_1~~																			
<9>	M_ME_NA_1	X	X	B											B					
~~<10>~~	~~M_ME_TA_1~~																			
<11>	M_ME_NB_1	X	X	B											B					
~~<12>~~	~~M_ME_TB_1~~																			
<13>	M_ME_NC_1	X	X	B											B					
~~<14>~~	~~M_ME_TC_1~~																			
<15>	M_IT_NA_1	X		B												B				
~~<16>~~	~~M_IT_TA_1~~																			
~~<17>~~	~~M_EP_TA_1~~																			
~~<18>~~	~~M_EP_TB_1~~																			
~~<19>~~	~~M_EP_TC_1~~																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1	X		B		X						X			X					
<31>	M_DP_TB_1	X		B		X						X			X					
<32>	M_ST_TB_1	X		B		X						X			X					
<33>	M_BO_TB_1	X		B		X									X					
<34>	M_ME_TD_1	X		B		X									X					
<35>	M_ME_TE_1	X		B		X									X					
<36>	M_ME_TF_1	X		B		X									X					
<37>	M_IT_TB_1	X		B											X	B				
<38>	M_EP_TD_1			X																
<39>	M_EP_TE_1			X																
<40>	M_EP_TF_1			X																
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X	X
<48>	C_SE_NA_1						X	X	X	X	X						X	X	X	X
<49>	C_SE_NB_1						X	X	X	X	X						X	X	X	X

Type Identification		Cause of transmission																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<50>	C_SE_NC_1						X	X	X	X	X						X	X	X	X
<51>	C_BO_NA_1						X	X	X	X	X						X	X	X	X
<58>	C_SC_TA_1						X	X	X	X	X						X	X	X	X
<59>	C_DC_TA_1						X	X	X	X	X						X	X	X	X
<60>	C_RC_TA_1						X	X	X	X	X						X	X	X	X
<61>	C_SE_TA_1						X	X	X	X	X						X	X	X	X
<62>	C_SE_TB_1						X	X	X	X	X						X	X	X	X
<63>	C_SE_TC_1						X	X	X	X	X						X	X	X	X
<64>	C_BO_TA_1						X	X	X	X	X						X	X	X	X
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						B	B	X	X	B						B	B	B	B
<101>	C_CI_NA_1						B	B			B						B	B	B	B
<102>	C_RD_NA_1					X											X	X	X	X
<103>	C_CS_NA_1						X	X										X		
~~<104>~~	~~C_TS_NA_1~~																			
<105>	C_RP_NA_1*)						X	X										X		
~~<106>~~	~~C_CD_NA_1~~																			
<107>	C_TS_TA_1						B	B									B	B	B	B
<110>	P_ME_NA_1						X	X												
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1						X	X									X	X	X	X
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1*)																			

*) blank or X only

6.6 Basic application functions

Station initialization
(station-specific parameter, mark '**X**' if function is used)

[X] Remote initialization

Cyclic data transmission
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X] Cyclic data transmission

Read procedure
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X] Read procedure

Spontaneous transmission
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[B] Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous
(station-specific parameter, mark each information type '**X**' where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

[X] Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1

[X] Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

[X] Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

[X] Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)

[X] Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and

[X] Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1

[X] Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and

Station interrogation
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[B] global			
[X] group 1	[X] group 7	[X] group 13	
[X] group 2	[X] group 8	[X] group 14	
[X] group 3	[X] group 9	[X] group 15	
[X] group 4	[X] group 10	[X] group 16	
[X] group 5	[X] group 11		
[X] group 6	[X] group 12		

Information Object Addresses assigned to each group must be shown in a separate table

Clock synchronization
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- [X] Clock synchronization
- [X] Day of week used
- [ ] RES1, GEN (time tag substituted/ not substituted) used
- [X] SU-bit (summertime) used

optional, see clause 7.6

Command transmission
(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- [X] Direct command
- [X] Direct set point command transmission
- [X] Select and execute command
- [X] Select and execute set point command
- [X] C_SE ACTTERM used

- [X] No additional definition
- [X] Short pulse duration (duration determined by a system parameter in the
- [X] Long pulse duration (duration determined by a system parameter in the
- [ ] Persistent output

- [X] Supervision of maximum delay in command direction of commands and set point

[adjustable] Maximum allowable delay of commands and set point

Transmission of integrated totals
(station- or object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[B] Mode A: Local freeze with spontaneous transmission
[B] Mode B: Local freeze with counter interrogation
[X] Mode C: Freeze and transmit by counter interrogation
[X] Mode D: Freeze by counter interrogation command, frozen values reported

[B] Counter read
[X] Counter freeze without reset
[X] Counter freeze with reset
[X] Counter reset

[B] General request
[B] Request counter group 1
[B] Request counter group
[B] Request counter group 3
[B] Request counter group 4

Parameter loading
(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X] Threshold value
[X] Smoothing factor
[ ] Low limit for transmission of measured
[ ] High limit for transmission of measured

Parameter activation
(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[ ] Act/deact of persistent cyclic or periodic transmission of the addressed

Test procedure
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[B] Test

File transfer
(station-specific parameter, mark '**X**' if function is used)

File transfer in monitor direction

[ ] Transparent file

[ ] Transmission of disturbance data of protection

[ ] Transmission of sequences of events

[ ] Transmission of sequences of recorded analogue values

File transfer in control direction

[ ] Transparent file

Background scan
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X] Background scan

Acquisition of transmission delay
(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[■] ~~Acquisition of transmission delay~~

Definition of time outs

Parameter	Default value	Remarks	Selected value
t_0	30s	Time out of connection establishment	
t_1	15s	Time out of send or test APDUs	
t_2	10s	Time out for acknowledges in case of no data messages $t_2 < t_1$	
t_3	20s	Time out for sending test frames in case of a long idle state	

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I format APDUs k and latest acknowledge

Parameter	Default value	Remarks	Selected value
k	12 APDUs	Maximum difference receive sequence number to send state variable	
w	8 APDUs	Latest acknowledge after receiving w I-format APDUs	

Maximum range of values k: 1 to 32767 (2^{15}-1) APDUs, accuracy 1 APDU
Maximum range of values w: 1 to 32767 APDUs, accuracy 1 APDU (Recommendation: w should not exceed 2/3 of k).

Portnumber

Parameter	Value	Remarks
Portnumber	2404	In all cases

Redundant connections

2 [1] Number N of redundancy group connection used

[1] During the test 2 redundancy groups were configured. The SUT supports more groups, but this was not tested.

RFC 2200 suite

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

☒ Ethernet 802.3
☐ Serial X.21 interface
☐ Other selection from RFC 2200:

List of valid documents from RFC 2200

1. ……..
2. ……..
3. ……..
4. ……..
5. ……..
6. ……..
7. etc.

.

APPENDIX A – TEST RESULTS CHART

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right		Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).		Controlling station	Controlled station	Normal Direction	Reversed Direction
Frame length	**5.2.0.1**	**Maximum length L (control direction)**	**N.A.**	√	√	√
	5.2.0.2	**Maximum length L (monitor direction)**	**N.A.**	√	√	√
Common Address of ASDU	**5.2.0.70**	**Two (2) octets for Common Address of ASDU (CASDU)**	**N.A.**	√	√	√
Information Object Address	**5.2.0.80**	**Three (3) octets for Information Object Address (structured or unstructured)**	**N.A.**	√	√	√
Cause of Transmission	**5.2.0.90**	**Two (2) octets for COT field (2nd octet is Originator address)**	**N.A.**	√	√	√
Tests on Transport Provider Level	**5.3.1.1**	**IP Frame**	**N.A.**	√	√	√
	5.3.1.3	**TCP Frame**	**N.A.**	√	√	√
	5.3.1.10	**CS104 Frame Layout**	**N.A.**	√	√	√
	5.3.1.20	**CS104 I-Format APDU**	**N.A.**	√	√	√
	5.3.1.25	**CS104 S-Format APDU**	**N.A.**	√	√	√
	5.3.1.30	**CS104 U-Format APDU**	**N.A.**	√	√	√
	5.3.1.50	**Transmission Procedure**	**N.A.**	√ [2]	√	√
	5.3.1.70	**Transmission Control Using START/STOP**	**N.A.**	√	√	√
	5.3.1.90	**Time Out Intervals**	**N.A.**	√	√	√
Verification of Data	**5.3.2.1**	**Type Identification**	**N.A.**	√	√	√

[2] The K (Transmitted unacknowledged frames) and W (Acknowledge received I frames) values are tested with K = 6 and W = 4.

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right		Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).		Controlling station	Controlled station	Normal Direction	Reversed Direction
Unit Identifier	**5.3.2.10**	**Cause of Transmission**	**N.A.**	√	√	√
	5.3.2.20	**Common Address of ASDU**	**N.A.**	√	√	√
Verification of ASDUs	**5.3.3.10**	**ASDU 1 Single-point Information**	**N.A.**	√	√	√
	5.3.3.30	**ASDU 3 Double-point Information**	**N.A.**	√	√	√
	5.3.3.50	**ASDU 5 Step-position Information**	**N.A.**	√	√	√
	5.3.3.70	**ASDU 7 Bitstring of 32 bit**	**N.A.**	√	√	√
	5.3.3.90	**ASDU 9 Measured value, normalised value**	**N.A.**	√	√	√
	5.3.3.110	**ASDU 11 Measured value, scaled value**	**N.A.**	√	√	√
	5.3.3.130	**ASDU 13 Measured value, short floating point number**	**N.A.**	√	√	√
	5.3.3.150	**ASDU 15 Integrated Totals**	**N.A.**	√	√	√
	5.3.3.170	**ASDU 20 Packed single-point information with status change detection**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.3.190	**ASDU 21 Measured value, normalised value without quality descriptor**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.3.210	**ASDU 30 Single-point information with time tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.230	**ASDU 31 Double-point information with time tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.250	**ASDU 32 Step-position information with time-tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.280	**ASDU 33 Bitstring of 32 bit with time-tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.310	**ASDU 34 Measured value, normalised value with time-tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.340	**ASDU 35 Measured value, scaled value with time-tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.370	**ASDU 36 Measured value, short floating point number with time-tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.400	**ASDU 37 Integrated totals with time tag CP56Time2a**	**N.A.**	√	√	√
	5.3.3.430	**ASDU 38 Event of protection equipment with time-tag CP56Time2a**	**N.A.**	√	√	**N.A.**
	5.3.3.460	**ASDU 39 Packed start events of protection equipment with time-tag CP56Time2a**	**N.A.**	√	√	**N.A.**

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right		Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).		Controlling station	Controlled station	Normal Direction	Reversed Direction
	5.3.3.490	**ASDU 40 Packet output circuit information of protection equipment with time tag CP56Time2a**	**N.A.**	√	√	**N.A.**
	5.3.4.1	**ASDU 45 Single Command**	**N.A.**	√ [3]	√	**N.A.**
	5.3.4.10	**ASDU 46 Double Command**	**N.A.**	√ [4]	√	**N.A.**
	5.3.4.20	**ASDU 47 Regulating step command**	**N.A.**	√ [5]	√	**N.A.**
	5.3.4.30	**ASDU 48 Set point command, normalised value**	**N.A.**	√	√	**N.A.**
	5.3.4.40	**ASDU 49 Set point command, scaled value**	**N.A.**	√	√	**N.A.**
	5.3.4.50	**ASDU 50 Set point command, short floating point value**	**N.A.**	√	√	**N.A.**
	5.3.4.60	**ASDU 51 Bitstring of 32 bits**	**N.A.**	√	√	**N.A.**
	5.3.4.70	**ASDU 58 Single command with time tag CP56Time2a**	**N.A.**	√ [6]	√	**N.A.**
	5.3.4.90	**ASDU 59 Double command with time tag CP56Time2a**	**N.A.**	√ [7]	√	**N.A.**
	5.3.4.110	**ASDU 60 Regulating step command with time tag CP56Time2a**	**N.A.**	√ [8]	√	**N.A.**
	5.3.4.130	**ASDU 61 Set point command, normalised value with time tag CP56Time2a**	**N.A.**	√	√	**N.A.**
	5.3.4.150	**ASDU 62 Set point command, scaled value with time tag CP56Time2a**	**N.A.**	√	√	**N.A.**
	5.3.4.170	**ASDU 63 Set point command, short floating point value with time tag CP56Time2a**	**N.A.**	√	√	**N.A.**
	5.3.4.190	**ASDU 64 Bitstring of 32 bits with time tag CP56Time2a**	**N.A.**	√	√	**N.A.**
	5.3.5.1	**ASDU 70 End of Initialisation**	**N.A.**	√ [9]	√	√

[3] Persistent output (QU = 3) is not supported.
[4] Persistent output (QU = 3) is not supported.
[5] Persistent output (QU = 3) is not supported.
[6] Persistent output (QU = 3) is not supported.
[7] Persistent output (QU = 3) is not supported.
[8] Persistent output (QU = 3) is not supported.

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right		Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).		Controlling station	Controlled station	Normal Direction	Reversed Direction
	5.3.6.1	**ASDU 100 Interrogation command**	**N.A.**	√	√	√
	5.3.6.10	**ASDU 101 Counter interrogation command**	**N.A.**	√	√	√
	5.3.6.20	**ASDU 102 Read command**	**N.A.**	√	√	**N.A.**
	5.3.6.30	**ASDU 103 Clock synchronisation command**	**N.A.**	√	√	**N.A.**
	5.3.6.60	**ASDU 105 Reset process command**	**N.A.**	√	√	**N.A.**
	5.3.7.70	**ASDU 107 Test command with time tag CP56Time2a**	**N.A.**	√	√	√
	5.3.7.1	**ASDU 110 Parameter of measured value, normalised value**	**N.A.**	√	√	**N.A.**
	5.3.7.10	**ASDU 111 Parameter of measured values, scaled value**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.7.20	**ASDU 112 Parameter of measured values, short floating point number**	**N.A.**	√	√	**N.A.**
	5.3.7.30	**ASDU 113 Parameter activation**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.8.1	**ASDU 120 File ready**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.8.10	**ASDU 121 Section ready**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.8.30	**ASDU 122 Call directory, select file, call file, call section**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.8.40	**ASDU 123 Last section, last segment**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.8.50	**ASDU 124 ACK file, ACK section**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.8.60	**ASDU 125 Segment**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.3.8.70	**ASDU 126 Directory**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
Data Unit Identifier	**5.4.9.1**	**Type Identification**	**N.A.**	√	√	√
	5.4.9.4	**Cause Of Transmission**	**N.A.**	√	√	√
	5.4.9.10	**Common Address of ASDU**	**N.A.**	√	√	√

[9] SUT only support End of Init with COI = 0 (Local power switch on)

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right	Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).	Controlling station	Controlled station	Normal Direction	Reversed Direction
Information object address	**5.4.10.1 Object Address**	**N.A.**	√	√	√
Station initialisation function	**5.4.11.1 Local Initialisation of the Controlling station: (re-)boot**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.11.10 Local initialisation of the Controlled station: (re-)boot	**N.A.**	√	√	√
	5.4.11.20 Remote initialisation of the Controlled station	**N.A.**	√	√	**N.A.**
	5.4.11.30 Re-establishing a lost Started connection between the Controlling and the Controlled station when no other connections are available	**N.A.**	√	√	√
	5.4.11.40 Compatibility With Other Test Cases	**N.A.**	√	√	√
Redundant Link	**5.4.12.1 Periodic check of ALL redundant connections**	**N.A.**	√ [10]	√	√
	5.4.12.10 Re-establishing a lost Started connection between the Controlling and the Controlled station when redundant connections are available: (automatic switch-over)	**N.A.**	√	√	√
	5.4.12.20 Re-establishing a lost redundant connection between the Controlling and the Controlled station	**N.A.**	√	√	√
	5.4.12.30 Manual switching over the Started connection to another redundant Stopped connection: (manual switch-over)	**N.A.**	√	√	√
Cyclic data transmission function	**5.4.13.1 Cyclic data transmission and Background Scan – sequential procedure**	**N.A.**	√	√	**N.A.**
	5.4.13.10 Compatibility With Other Test Cases	**N.A.**	√	√	**N.A.**
Data acquisition through Read function	**5.4.14.1 Data acquisition through Read - sequential procedure**	**N.A.**	√	√	**N.A.**
	5.4.14.10 Compatibility With Other Test Cases	**N.A.**	√	√	**N.A.**
Acquisition of events function	**5.4.15.1 Acquisition of events -sequential procedure**	**N.A.**	√	√	√
	5.4.15.10 Compatibility With Other Test Cases	**N.A.**	√	√	√

[10] Redundant connections are tested with 2 connections in 1 redundancy group and with 2 connections in 2 separate redundancy groups (with 2 different Originator addresses). In case of 2 separate redundancy groups: If an event occurs, and one of the connections is stopped or not connected, then the event will be retransmitted when that connections becomes started again. Only events will be retransmitted, other data (such as GI data) is not retransmitted.

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right	Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).	Controlling station	Controlled station	Normal Direction	Reversed Direction
General interrogation function	**5.4.16.1 Outstation interrogation - one Logical Remote Unit (LRU) available in the controlled station -**	**N.A.**	√ [11]	√	√
	5.4.16.10 Outstation interrogation - more than one Logical Remote Unit (LRU) available in the controlled station -	**N.A.**	√	√	√
	5.4.16.20 Re-activate a running Outstation interrogation - Option 1: the running GI continues.	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.16.30 Re-activate a running Outstation interrogation Option 2: the running GI is stopped and the second GI is started.	**N.A.**	√	√	**N.A.**
	5.4.16.40 Re-activate a running Outstation interrogation Option 3: the running GI continues and after activation termination (COT=10) the second GI is started. (Option 3 can be described as undesirable behaviour!!)	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.16.50 Deactivate a running Outstation interrogation	**N.A.**	√	√	**N.A.**
	5.4.16.60 Compatibility With Other Test Cases	**N.A.**	√	√	√
Clock synchronisation function	**5.4.17.1 Clock synchronisation -sequential procedure**	**N.A.**	√	√	**N.A.**
	5.4.17.10 Clock synchronisation – Change the clock	**N.A.**	√	√	**N.A.**
	5.4.17.20 Compatibility With Other Test Cases	**N.A.**	√	√	**N.A.**
Command transmission function	**5.4.18.1 Select & Execute**	**N.A.**	√ [12]	√	**N.A.**
	5.4.18.10 Select & Deactivation	**N.A.**	√	√	**N.A.**
	5.4.18.20 Direct Execute	**N.A.**	√ [13]	√	**N.A.**
	5.4.18.30 Select with Negative Confirmation by Controlled station (Abort)	**N.A.**	√	√	**N.A.**
	5.4.18.40 Select with Negative Execute Confirmation by Controlled station if Execute is received after configured delay in the controlling station	**N.A.**	√	√	**N.A.**

[11] SUT can send GI data with and without time stamp and with SQ=0 or SQ=1.
[12] SUT does not support command qualifier Persitant Output
[13] SUT does not support command qualifier Persitant Output

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right	Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).	Controlling station	Controlled station	Normal Direction	Reversed Direction
	5.4.18.50 Direct Execute with Negative Confirmation by Controlled station	**N.A.**	√	√	**N.A.**
	5.4.18.60 Command transmission with network delay supervision - sequential procedure:Command received WITHIN configured delay	**N.A.**	√	√	**N.A.**
	5.4.18.70 Command transmission with network delay supervision - sequential procedure:Command received AFTER configured delay	**N.A.**	√	√	**N.A.**
	5.4.18.80 Test for all supported ASDU's	**N.A.**	√	√	**N.A.**
	5.4.18.90 Compatibility With Other Test Cases	**N.A.**	√	√	**N.A.**
Transmission of integrated totals (telecounting) function	**5.4.19.1 Mode A - Local freeze with spontaneous transmission**	**N.A.**	√	√	√
	5.4.19.10 Mode B - Local freeze with Counter Interrogation	**N.A.**	√	√	√
	5.4.19.20 Mode C – Remote initiated freeze with Counter Interrogation	**N.A.**	√	√	**N.A.**
	5.4.19.30 Mode D – Remote initiated freeze with spontaneous transmission	**N.A.**	√	√	**N.A.**
	5.4.19.40 Compatibility With Other Test Cases	**N.A.**	√	√	√
Parameter loading function	**5.4.20.1 Load and activate parameter**	**N.A.**	√	√	**N.A.**
	5.4.20.10 Load and activate parameter with Negative Confirmation by Controlled station	**N.A.**	√ [14]	√	**N.A.**
	5.4.20.20 Compatibility With Other Test Cases	**N.A.**	√	√	**N.A.**
Test procedure function	**5.4.21.1 Test procedure - sequential procedure**	**N.A.**	√	√	√
	5.4.21.10 Compatibility With Other Test Cases	**N.A.**	√	√	√
File transfer procedure function	**5.4.22.1 File transfer procedure (monitor direction) – sequential procedure**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.22.10 File transfer procedure (control direction) – sequential procedure	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.22.20 Compatibility With Other Test Cases	**N.A.**	**N.A.**	**N.A.**	**N.A.**

[14] When a paramater is loaded with a negative value, the SUT responds with negative activation confirmation and the current value

	Record the Conformance Test Procedure result for each of the supported configuration parameter values on the right	Station Type		Direction	
	√ indicates the Test Procedure PASSED for that configuration value. FAIL indicates Test Procedure failed for at least one of the Test Cases. N.A. indicates that configuration value is not supported by the device. Empty indicates the Test Procedure was not performed. (There should be no empty boxes when testing is complete).	Controlling station	Controlled station	Normal Direction	Reversed Direction
Additional Conformance Test Procedures	**5.4.23.1 Out of service behaviour**	**N.A.**	√	√	**N.A.**
	5.4.23.10 Miscellaneous	**N.A.**	√ [15]	√	**N.A.**
	5.4.23.20 Time invalid	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.23.30 Compatibility With Other Test Cases	**N.A.**	√	√	**N.A.**
Negative Conformance Test Procedures	**5.4.24.1 Negative tests**	**N.A.**	√	√	**N.A.**
	5.4.24.50 Compatibility With Other Test Cases	**N.A.**	√	√	**N.A.**
PIXIT related Conformance Test Procedures	**5.4.25.1 Function:**	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.25.50 Function:	**N.A.**	**N.A.**	**N.A.**	**N.A.**
	5.4.25.100 Function:	**N.A.**	**N.A.**	**N.A.**	**N.A.**

[15] When the SUT receives an Activation for a not supported Basic Application Function, it will ignore the frame.

APPENDIX B-1 – TEST RESULTS OF SINGLE COMMAND TRANSMISSION

TEST RESULTS OF THE SINGLE COMMAND (SCO) '√' = tested '-' = not tested Detailed information on enclosures per Command type. The datalink services are not shown in the details, only the command ASDUs. Each IOA could be configured S/E or only E. S+E on/off = Select & Execute command on/off S & D = Select & Deactivate command on/off E on/off = Direct Execute command on/off	ACTCONpos=Positive Activation Confirmation ACTCONneg=Negative Activation Confirmation DEACTCONpos=Deactivation Confirmation positive ACTTERM=Activation Termination If ACTTERM is stated in row 'message from the RTU', ACTCONpos with S/E=0 execute has been received before. In case of a S+E command also ACTCONpos with S/E=1 select has been received before the ACT with S/E=0! NOTE: this table shows the only correct behaviour. Other behaviour means the test failed!

ASDU type = 45	S+E on	S+E off	S+D on	S+D off	Eon	Eoff
QU=0 (no add. def.)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=1 (short pulse)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=2 (long pulse)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI

Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=3 (persistent)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	-	-	-	-	-	-
Log file available (Y/N)?	N	N	N	N	N	N
General remarks	• √					

APPENDIX B-2 – TEST RESULTS OF DOUBLE COMMAND TRANSMISSION

TEST RESULTS OF THE DOUBLE COMMAND (DCO) '√' = tested '-' = not tested Detailed information on enclosures per Command type. The datalink services are not shown in the details, only the command ASDUs. Each IOA could be configured S/E or only E. S+E on/off = Select & Execute command on/off S & D = Select & Deactivate command on/off E on/off = Direct Execute command on/off	ACTCONpos=Positive Activation Confirmation ACTCONneg=Negative Activation Confirmation DEACTCONpos=Deactivation Confirmation positive ACTTERM=Activation Termination If ACTTERM is stated in row 'message from the RTU', ACTCONpos with S/E=0 execute has been received before. In case of a S+E command also ACTCONpos with S/E=1 select has been received before the ACT with S/E=0! NOTE: this table shows the only correct behaviour. Other behaviour means the test failed!

ASDU type = 46	S+E on	S+E off	S+D on	S+D off	Eon	Eoff
QU=0 (no add. def.)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=1 (short pulse)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=2 (long pulse)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI

Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=3 (persistent)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	-	-	-	-	-	-
Log file available (Y/N)?	N	N	N	N	N	N
General remarks	• √					

APPENDIX B-3 – TEST RESULTS OF REGULATING STEP COMMAND TRANSMISSION

TEST RESULTS OF THE REGULATING STEP COMMAND (RCO) '√' = tested '-' = not tested Detailed information on enclosures per Command type. The datalink services are not shown in the details, only the command ASDUs. Each IOA could be configured S/E or only E. S+E on/off = Select & Execute command on/off S & D = Select & Deactivate command on/off E on/off = Direct Execute command on/off	ACTCONpos=Positive Activation Confirmation ACTCONneg=Negative Activation Confirmation DEACTCONpos=Deactivation Confirmation positive ACTTERM=Activation Termination If ACTTERM is stated in row 'message from the RTU', ACTCONpos with S/E=0 execute has been received before. In case of a S+E command also ACTCONpos with S/E=1 select has been received before the ACT with S/E=0! NOTE: this table shows the only correct behaviour. Other behaviour means the test failed!

ASDU type = 47	S+E up	S+E down	S+D up	S+D down	E up	E down
QU=0 (no add. def.)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=1 (short pulse)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=2 (long pulse)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI

Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√	√	√	√
Log file available (Y/N)?	Y	Y	Y	Y	Y	Y
QU=3 (persistent)						
Message from RTU	ACTTERMpos	ACTTERMpos	DEACTCONpos	DEACTCONpos	ACTTERMpos	ACTTERMpos
Shown behaviour after Select / Execute	E	E	S or E	S or E	E	E
Status change RTU	Yes, HMI	Yes, HMI	No	No	Yes, HMI	Yes, HMI
Status change process	If available	If available	No	No	If available	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	-	-	-	-	-	-
Log file available (Y/N)?	N	N	N	N	N	N
General remarks	• √					

APPENDIX B-4 – TEST RESULTS OF SETPOINT COMMAND TRANSMISSION

TEST RESULTS OF THE SETPOINT COMMAND (NVA) 'X' = tested '-' = not tested Detailed information on enclosures per Command type. The datalink services are not shown in the details, only the command ASDUs. Each IOA could be configured S/E or only E. They should not be able to support both at a time. S+E on/off = Select & Execute command on/off S & D = Select & Deactivate command on/off E on/off = Direct Execute command on/off	ACTCONpos=Positive Activation Confirmation ACTCONneg=Negative Activation Confirmation DEACTCONpos=Deactivation Confirmation positive ACTTERM=Activation Termination If ACTTERM is stated in row 'message from the RTU', ACTCONpos with S/E=0 execute has been received before. In case of a S+E command also ACTCONpos with S/E=1 select has been received before the ACT with S/E=0! NOTE: this table shows the only correct behaviour. Other behaviour means the test failed!

ASDU type = 48	S+E	S+D	E
QL=0			
Message from RTU	ACTCONpos / ACTTERMpos[16]	DEACTCONpos	ACTCONpos / ACTTERMpos[16]
After S or E	E	S or E	E
Status change RTU	Yes, HMI	No	Yes, HMI
Status change process	If available	No	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√
Log files available (Y/N)?	Y	Y	Y
General remarks	• √		

[16] If the PICS states ACTTERM is used ACTTERM is applicable, if not ACTCON is applicable.

APPENDIX B-5 – TEST RESULTS OF SETPOINT COMMAND TRANSMISSION

TEST RESULTS OF THE SETPOINT COMMAND (SVA) 'X' = tested '-' = not tested Detailed information on enclosures per Command type. The datalink services are not shown in the details, only the command ASDUs. Each IOA could be configured S/E or only E. They should not be able to support both at a time. S+E on/off = Select & Execute command on/off S & D = Select & Deactivate command on/off E on/off = Direct Execute command on/off	ACTCONpos=Positive Activation Confirmation ACTCONneg=Negative Activation Confirmation DEACTCONpos=Deactivation Confirmation positive ACTTERM=Activation Termination If ACTTERM is stated in row 'message from the RTU', ACTCONpos with S/E=0 execute has been received before. In case of a S+E command also ACTCONpos with S/E=1 select has been received before the ACT with S/E=0! NOTE: this table shows the only correct behaviour. Other behaviour means the test failed!

ASDU type = 49	S+E	S+D	E
QL=0			
Message from RTU	ACTCONpos / ACTTERMpos[17]	DEACTCONpos	ACTCONpos / ACTTERMpos[16]
After S or E	E	S or E	E
Status change RTU	Yes, HMI	No	Yes, HMI
Status change process	If available	No	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√
Log files available (Y/N)?	Y	Y	Y
General remarks	• √		

[17] If the PICS states ACTTERM is used ACTTERM is applicable, if not ACTCON is applicable.

APPENDIX B-6 – TEST RESULTS OF SETPOINT COMMAND TRANSMISSION

TEST RESULTS OF THE SETPOINT COMMAND (IEEE STD 754) 'X' = tested '-' = not tested Detailed information on enclosures per Command type. The datalink services are not shown in the details, only the command ASDUs. Each IOA could be configured S/E or only E. They should not be able to support both at a time. S+E on/off = Select & Execute command on/off S & D = Select & Deactivate command on/off E on/off = Direct Execute command on/off	ACTCONpos=Positive Activation Confirmation ACTCONneg=Negative Activation Confirmation DEACTCONpos=Deactivation Confirmation positive ACTTERM=Activation Termination If ACTTERM is stated in row 'message from the RTU', ACTCONpos with S/E=0 execute has been received before. In case of a S+E command also ACTCONpos with S/E=1 select has been received before the ACT with S/E=0! NOTE: this table shows the only correct behaviour. Other behaviour means the test failed!

ASDU type = 50	S+E	S+D	E
QL=0			
Message from RTU	ACTCONpos / ACTTERMpos[18]	DEACTCONpos	ACTCONpos / ACTTERMpos[16]
After S or E	E	S or E	E
Status change RTU	Yes, HMI	No	Yes, HMI
Status change process	If available	No	If available
Required	PICS, 9.5 8.6	PICS, 9.5 8.6	PICS, 9.5 8.6
Result	√	√	√
Log files available (Y/N)?	Y	Y	Y
General remarks	• √		

[18] If the PICS states ACTTERM is used ACTTERM is applicable, if not ACTCON is applicable.